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UNITED STATES DEPARTMENT OF AGRICULTURE

# FOREST SERVICE

## FOREST FIRES IN THE SOUTHERN COASTAL PLAIN

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New Orleans, La.

Revision of
June 10, 1924

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## OBJECT AND SCOPE

First in importance among the projects of the Southern Forest Experiment Station is a silvicultural study of forest fires. As a preliminary to dividing this large subject into its many phases, and drawing up working plans for the investigation of each, it has seemed desirable to compile a general statement covering what is known or believed about fires in their effect on the forest of the Southern Coastal Plain. Altho the territory assigned to the Station includes the Piedmont as well, its fire problems are not discussed here, being of minor importance.

How little reliable information we have on these forest fires is well shown by the poverty of written material on the subject., and the wide differences of opinion,/ Individual states have published considerable anti-fire propaganda, dealing strictly with local conditions, but have not attempted to paint a broad picture of the regional problem. The nearest approach is a very brief summary of the U.S. Department of Agriculture. (1)

## WIDE VARIETY OF CONDITIONS

As a forest region the Coastal Plain extends through all of the South Atlantic and Gulf Coast states, or from Virginia to Texas. (As a geologic province it stretches from Cape Cod to Mexico.) There is here a larger area of nearly continuous forest land than in any other portion of the United States. Too great emphasis cannot be laid on the fact that in this great stretch of country, embracing probably 150 million acres of forested or cut-over land from the Potomac to the Brazos, there is a large variation in soil, topography, climate, and vegetation. Thus, although sandy soils predominate, there are important areas of silt and silt loam, and within the soil provinces which the layman would classify as sandy* there is every variation in character between seemlingly bottomless sands and those underlain at a few inches by clays. Similarly, despite the general levelness characteristic of a plain, the topography varies from dreary "crawfish" flats to 500-foot hills. Even greater variations are introduced by including in the region, because of similarities in forest growth, the Ouachita Mountains of Arkansas, where shortleaf pine grows on rocky hills 1900 feet above sea-level. The typical forest of the Coastal Plain is pine, including half a dozen important species, but a very large number of other species also occur, as later described. Owing to this diversity of conditions it is dangerous to make broad statements which have the appearance of being intended

*According to the classification of the Bureau of Soils many soils whose surface layers are nearly pure sand are described as loams, because of the subsoils under them.

to apply to the whole territory under consideration.* Even in adjoining counties, conditions of soil, topography, and resulting vegetation may differ so sharply that the fire problem assumes widely varying aspects.

EXTENT AND CAUSE OF FIRES IN THE COASTAL PLAIN

43% of the forest fires reported in the entire United States during the period 1916-22, and nearly 70% of the area burned, were in nine Southern states. As state forestry departments, charged with fire protection, do not now exist in South Carolina, Georgia, Florida, Mississippi, Arkansas, and Oklahoma, fire statistics from these states are only approximations, and are certainly conservative. Although the data is not available for the Coastal Plain and higher portions of these states separately, it is safe to say that an overwhelming proportion of the fires and the acreage is in the Coastal Plain. (2) Except for the deepest cypress swamps, or for small acreages lying in the vicinity of ploughed fields, one can go nowhere in this vast region without finding plain proof that fires have burned within ten years. In the pine woods proper, and particularly the longleaf pine woods, fires have generally occurred about eight years out of ten with the most pitiless regularity. In some portions of the Coastal Plain two fires a year are not out of the ordinary.

The woods are widely and systematically burned in the Coastal Plain because those who run cattle and other live-



*Footnote (from attached sheet)

(Footnote, page 3)

The State Forester of Virginia, in response to requests for criticism of this manuscript, has pointed out that there are important differences between the Coastal Plain as a whole and that portion of it lying west of the Dismal Swamp in Virginia. It has seemed inadvisable to attempt to qualify a large number of passages on succeeding pages in order to make them fit special conditions in this relatively small portion of the Coastal Plain. The better plan has seemed to summarize here the chief respects in which Virginia conditions differ from the more general conditions, according to Alfred Akerman of the State Forester's staff: Fires started by stockmen are rare, because there is little "free", or unfenced, range. There are no turpentine orchards at all. Except in abandoned fields pine rarely grows in pure stands; hardwoods are "in almost all cases an important part of the stand" in which pine appears. Grass is less important than farther South as a fuel for woods fires. Those who favor burning are in the minority. (This is also becoming true of other Southern states in which forestry departments have functioned for several years.)

stock there, largely on land belonging to some one else, believe that fire improves the forage, kills the ticks, redbugs, and other insects noxious to animals and men, and makes more livable and traversable vast areas which are used only for grazing. Fires are, of course, kindled in many other ways, but deliberate and systematic use of fire is very largely confined to the stockmen. Pine knot gatherers sometimes burn off the grass to expose the material they are seeking. In addition, the naval stores operator burns his orchards after raking around the trees every winter. But he defends his action, as does the farmer who burns around his fences periodically, by maintaining that he is obliged to do what he can to reduce the risk of being "burned out" by the stockmen at some dangerous time.

There are three main forest types in the Southern Coastal Plain, and a fourth of much less importance. Briefly described, these are the pine type, including longleaf and slash pine in the coast regions, and shortleaf and loblolly pine further inland; the hardwood type, chiefly in the river bottoms; and the cypress and tupelo swamps. The fourth, unimportant in acreage, is the so-called "juniper" type, or swamps of Southern white cedar (Chamaecyparis thyoides).

Of these the pine type suffers most frequently from fires. Its vegetation is highly inflammable, and because the pine for the most part occupies the higher land, the forest dries out in a shorter time and will burn during a

greater number of months in the year and a greater number of years in the century, than any of the three other types.

It is worth while to draw a line of distinction between the longleaf and shortleaf lands. Broadly speaking, longleaf pine occupies soils of less agricultural value than the shortleaf, loblolly, scrub, and other pines. It is natural, therefore, to find fewer cultural obstacles to the spread of fire in the longleaf lands than elsewhere. In the shortleaf pine country cultivated fields, roads connecting them, and to a certain extent topography, confine such fires as start to relatively small areas. Fires in the shortleaf forests rarely burn for days at a time, as they do in most parts of the longleaf pine region. The longleaf pine lands present the most serious fire problem of all the South.

Chiefly because the natural conditions are unfavorable, fires cover a much smaller per cent of the hardwood type than of the pine type. In a few localities, however, as for example the Yazoo Delta of Mississippi, fires in the hardwood bottoms occur nearly annually.

Perhaps once in twenty years a drought will be so prolonged as to make fires possible in the fringes of the cypress swamps. In 1917 cypress operators in Louisiana at least suffered some severe losses in burned timber and logging equipment.

The juniper type, being extremely wet, burns about as infrequently as the cypress swamps. Slash areas are an exception.

## CHARACTER OF THE HAZARD

Except when burning in slash, fires in the Coastal Plain of the South are rarely spectacular. In an extremely dry year crown fires may develop in dense stands of small pines or junipers. But the average fire consumes only the surface vegetation, without flaring up more than a few feet. The reason for this is the character of the inflammable material in the Southern woods and cut-over lands. The various inflammable elements of the vegetation are described in the following paragraphs. Grass, because of its importance, is described first.

Grass: Grass enables fires to spread rapidly and to cause damage. The abundant rainfall and long growing season of the Coastal Plain encourage luxuriant vegetative growth of all kinds, best typified by the rank stools of broom sedge (Andropogon sp.) and wire grass (Aristida, Muhlenbergia, et al, sp.). These are characteristic of the piney-woods, and are displaced by other equally rank vegetation in the wetter types. They appear wherever the stands of pine are at all open, but never in very dense sapling thickets on old fields. Once eradicated through cultivation, the wire grass does not appear to come back readily. A surprising amount of grass will be found even in well-stocked stands of longleaf, at practically every stage of their development. On cut-over land up to the time the young second-growth forms a canopy, and in open virgin timber, the grass is particularly abundant.

These grasses, especially the broom sedge, attain

a height of two to four feet in a normal year on cut-over land. The first heavy frost of autumn kills the stems and converts them into a fearful fire hazard. A summer drought has much the same effect as frost. If grazing is insufficient to keep down the growth - and only extreme hunger will cause livestock to consume the coarse stems of the broom sedge or the wiry stems of many other native grasses after early summer - the dead material becomes matted with the fresh growth and remains a hazard at all seasons of the year.

Litter: In addition to the grass, which affords the main fuel for surface fires, there is of course, a considerable leaffall in every forest type. In the cypress swamps standing water during the greater part of the year preserves the leaves and other vegetable matter, which accumulate to form a heavy layer. Once thoroughly dried out in a prolonged drought it is just as inflammable as the duff, or swamp litter, of our Northern and Western forests.

In the pine and most hardwood forests, however, a totally different condition exists. Any deeper accumulation of pine needles, even on land which has not burned for twelve or fifteen years, than about four inches, is rare. A long warm season and abundant moisture provide ideal conditions for organisms which attack the fallen leaves and for chemical action. Nevertheless, even four inches of thoroughly dried pine leaves can make a hot fire, and it

must not be inferred from the above that leaf litter is not an important factor in making possible the spread of fires within stands, and causing severe damage.

In the hardwood bottoms litter is, contrary to what one might expect, generally scanty over most of the forest floor. Altho decay and chemical action are no doubt important in producing this effect, flood water appears to be even more so. The larger bottoms are overflowed regularly every spring, unless levied. Those along small streams are not so often overflowed as covered by a few inches of water after every heavy rain thruout the year. In spite of low gradients, there is in all cases a decided current in the surface and overflow waters, which carries away such of the fallen leaves, twigs, and similar litter as will float. The greater part of the remainder is buried under silt when the water subsides. The floating material is of course caught by such obstructions as tree trunks, underbrush, and down timber, and causes a heavy litter in small, irregular patches. When thoroughly dried out such accumulations are highly inflammable. This drying, however, requires several weeks' drought, and normally only the surface layer will burn.

Frequent overflows in most of the cypress and tupelo type incorporate surface litter into a muck. Cypress swamps not subject to overflow, and all of the Southern white cedar swamps, preserve the litter and form a peat often several feet deep. When such peat dries out it is extremely combustible

Underbrush: With some exceptions, inflammable brush is not a very important factor in our fire situation.

Where pine comes up under anything like natural conditions, such as probably existed before the coming of the white man into the virgin forest, a good stand is always maintained, and underbrush is kept out of the shade and root competition of the trees. This is not quite so true of areas which originally had considerable hardwood mixed with the pine. What brush there is adds to the fire risk through the falling of the leaves more than in any other way. In rather wet sites, however, gallberry (Ilex glabra) grows very thickly in slash pine and loblolly pine stands, and its dead leaves and slender stems when well heated burn almost exposively. In cut-over pine lands there is often a very large amount of brush. Various species of the smaller oaks, (such as Q. marilandica, catesbeii, etc.) come up abundantly. These undoubtedly contribute by their leaffall to the inflammability of the forest and their persistent leaves will sometimes carry flames into their crowns. They are particularly abundant on rolling land with friable sub-soils.

In the hardwood bottoms underbrush is sometimes an important element in the fire hazard. If vines are included under this classification, mention must be made of a species locally known as buckvine (Campsis radicans), which in the Yazoo Delta of Mississippi creates a very high hazard by its luxuriant growth and the ready inflammability of its light leaves when dry. Because of its climbing habit, which keeps

it well off the ground and on other forms of vegetation, it becomes tinder soon after the first heavy frost. Wherever it grows, fire-fighting is extremely difficult. Palmetto is another species of bottomland underbrush which makes a very hot fire wherever abundant.

Trees: Very small pine saplings in stands approximately even-aged will, of course, be completely consumed if high wind drives a fire through them at a dry time. When occurring as an understory or advance growth in partially stocked older stands these same trees may communicate fire to the crowns of the larger trees, with disastrous results. Well-grown trees without an understory or heavy undergrowth do not suffer from crown fires. An exception to this is said to be sand or scrub pine (Pinus clausa). When fires occur in well-grown stands, they customarily climb into the crowns, aided apparently by a peculiarly pitch condition of the leaves which is reached only during extremely dry and hot spring weather.

Stands of second-growth Southern white cedar (Juniper) may, if the swamp has dried out in a prolonged drought, afford fuel for a crown fire.

Crown fires in hardwoods or in cypress, if they occur at all, are rare.

Slash and logging debris: As in every other forest region where close utilization in logging is not economically possible, slash, cull logs, broken unmerchantable timber, and similar debris are a very serious fire menace both to standing timber and reproduction in the Coastal Plain.

In the pine type it is probable that 25 per cent of the ground is covered by slash after ordinary logging. (3) Pine tops appear from the meagre data available to dry out sufficiently within a month or two of logging - the period depending on weather conditions - to make a very hot fire. A year after logging a portion of the needles have already fallen from the tops, but the hazard is probably not appreciably reduced for at least two or three years. Decay is largely dependent on the proportion of hardwood, which differs with the species. At 10 or 12 years loblolly and shortleaf pine tops, being mostly sapwood, have practically disappeared, and old logs are reduced to a state of decay in which they are not ignited by an ordinary surface fire. Longleaf logs and larger limbs, on the other hand, have a relatively large heart, which ~~differ~~ in time appears to be converted by chemical or physical processes into "lightwood", or wood of extraordinarily heavy resin content. This may remain on the ground for decades, and adds greatly to the severity of surface fires, although not a large factor in their spread. Where tops left in logging are removed for pulpwood down to 3" in diameter, longleaf pine slash ceases to be a real menace in two years.

Slash in the hardwood type burns fiercely if dried out promptly after logging, but if wet weather follows there is probably a good deal of variation. White oak tops may actually increase in hazard for a year or more following logging, and probably take about 10 years to disintegrate. Other more perishable hardwoods take much less time, sometimes as little

as three or four years. Southern white cedar slash, which in spite of close utilization may cover 50 to 60% of the ground, is a bad fire trap for a few months, and may remain so for five to ten years. Cypress is utilized closely, and the main

inflammable material in a cypress swamp after logging is the cull logs of tupelo or gum and timber broken in skidding, around the skidder set-ups, which are 800 feet apart on most operations. Not much of this will burn.

Turpentining: The chipping of longleaf and slash pines in naval stores operations produces a fire hazard peculiar to the industry. The cutting of a hollow, or box, at the base of the chipped tree to receive the gum of course created a great hazard which has now been largely eliminated through the substitution for the boxes of cups hung on the trees. The gum flows from a scarified "face" of varying height, but beginning about eight inches above the surface of the ground. Sometimes two or more faces are placed on a tree. Resin flowing over or hardening on this face is readily ignited by even a very light surface fire, unless the mineral soil has been exposed by raking away the grass, leaves and inflammable material from the base of the trees. Such raking is the universal practice in turpentine orchards, and is estimated to cost the naval stores operators of the South about half a million dollars annually. Annual raking will by no means prevent fires from getting into the faces, however, because a certain amount of bark, and dead leaves, and the chips removed from the ~~xxxxxxxx~~ face weekly during the season, readily communicate fire across the raked ground to the turpentined face. The extra hazard from turpentining continues during the period of from two to six years while

chipping is currently going on, and afterwards up to the time when the face heals completely over. The healing is a process of years, and may never be accomplished under repeated burning. The wounded trees are subject to constant attack by insects and decay, so that the butt logs up to the height of the faces are almost a total loss after a few years.

## FIRE SEASONS

There is no season of the year during which fires in the Southern piney-woods may not occur. It is this fact which complicates the work of fire protection in the Coastal Plain. No doubt because of the presence of elements in the vegetation which mature before fall, there is a certain amount of dry material on the ground by August of most years. In an abnormally dry year the proportion of such material is very greatly increased, and extensive surface fires may and do occur as early as July and August, or two or three months before frost. However, under normal conditions the bulk of the ground cover does not die and become inflammable much before the autumn frosts. (In Texas the season normally begins about September first, according to the State authorities.) From that time until a large amount of new growth, both grass and herbs, appears in the spring the Southern pine woods will burn practically independent of rainfall. The experimental plot (Roberts Plot) under fence at Urania, Louisiana, has been burned the day following a heavy rain, or following the melting of snow in the shadow of the seedlings, and the fire was hot enough to fuse the edges of broken glass lying on the ground. In the more level portions of the pine forests

it is by no means an uncommon experience for men to fight fire burning in broom sedge over two or three inches of standing water. A winter fire has been reported from Florida to burn furiously through palmetto in the shade of slash pine only half a day after drenching rains, and to scorch the trunks of the trees up to a height of 20 or 30 feet. The attached charts show the occurence of droughts in the course of twenty years in Louisiana, and will help the reader to understand why fires may occur in pine or even hardwood land at practically any season.

(Insert charts)

Conditions in Louisiana with regard to drought are not typical of the entire Coastal Plain. Records (5) show, for example, that whereas southwest Louisiana xxxxxxxx in the period between 1895 and 1914 experienced record droughts of from 60 to 80 days's duration during the growing season for crops, and east Louisiana droughts ran from 50 to 60 days, in southern Gerogia and northern Florida the maximum duration was 50 days. Further south in the Florida peninsula it is surprising to note that the maximum again rose to 80 days. Still more significant, it would seem, the percentage of years during which 30 consecutive days between March 1 and September 30 passed without 1/4 inch of rainfall in 24 hours, was also much greater in Louisiana than in the eastern portions of the Coastal Plain. The percentage for west Louisiana stations was 60 to 80, and for the rest of the state 50 to 60, in contrast to less than 30 in southern

Georgia and northern Florida. Coastal Plain rainfall is also apt to be "spotted", two stations but a few miles apart often showing wide differences for an entire year.

Although fires may burn during practically any month of the year in the Southern pine woods, they are most prevalent during two seasons - autumn, and late winter, or early spring. September is generally the driest month of the year in the South, and during this month and early October there are a great many fires. Incendiary fires are probably more frequent late in the winter, the months varying within the region in response to local custom, which is in turn based on local weather. At this time the majority of the stock-men in free range states consider it incumbent upon them to burn off the range. During December and January there are apt to be rather heavy rains, although this is by no means invariably the case. The season when fires are least likely to occur is the two or three months following visible vegetative awakening in the spring. This is, of course, due to the presence of green material, altho this is probably partly off-set by the leaf fall of many of the oaks, which hold their leaves over the winter, and of the pines, which shed their leaves throughout the twelve months.

Sand pine stands in the Florida peninsula are unique in experiencing their usual fire season during April and May. Frosts do not occur to kill the season's growth of surface vegetation which dries only with the lapse of time. The previous year's growth becomes thoroughly inflammable

after the start of new vegetation, and high temperatures and low seasonal precipitation are said to produce the peculiar pitchy condition of the needles on the standing pines earlier mentioned.

Cedar swamps will burn whenever the water table falls low enough to allow the surface to dry out thoroughly.

## THE EFFECT OF FIRES

The following statements relative to the effect of fires in the Coastal Plain will for the most part apply to burns occurring outside of the vegetative season. When fires occur during the vegetative period the damage which they cause is increased many-fold. For example, a fire which in January might merely singe the leaves off longleaf pines up to two or three feet in height, and cause those up to twelve or fifteen feet to lose the majority of their leaves, may in July or August kill trees twelve inches in diameter. Summer burns are comparatively rare, but it is well to keep them in mind in reading the following account of fire damage. Otherwise it would be easy to under-estimate the power of fire to damage the Southern forests.

## Effect upon Soil

Taking their cue from other regions where fires have long been studied, the first foresters in the South invariably spoke of the severe damage to the soil of the pine woods which they believed was caused by annual fires. These fires were described as consuming large amounts of vegetable matter, which if allowed to rot would add considerable fertility to the soil. While this idea may be correct under some conditions in the pine woods, it has been pointed out by the U. S. Bureau of Soils that this damage is ordinarily slight. Unless the layer of dead leaves, grass, and other forest debris on sandy land is mechanically mixed with the mineral soil by ploughing, or by the less effective rooting of hogs, it is said to have little effect in adding humus and nitrogen to the soil. As already indicated, a long warm season, with abundant moisture, fosters rapid decay and oxidation, resulting in the dissipation of surface layers of vegetable matter in the form of carbon dioxide and other gases, rather than their incorporation in the soil. Evidence of this is the extremely shallow discoloration of the mineral soil under even several years' accumulation of pine needles and similar material. Not more than a quarter of an inch of top soil thoroughly darkened by organic matter is ordinarily found. (It is of course conceivable that some available nitrogen is carried downward through the soil without causing discoloration of the surface layers.)

On the other hand, the surface mulch formed by litter must greatly increase the moisture-holding capacity of the soil below, and favor the growth of both trees and lesser vegetation. This automatically adds to soil fertility by encouraging the production of roots which, on the death of the plants, add to its humus content. European observations on the relation of forest and floods has brought out the fact that decaying vegetation is not in itself the valuable storage-house of moisture we once thought it, but performs an invaluable function in keeping the soil below in a condition to store rainfall. Fires therefore do important damage when they destroy the surface mulch.

In the hardwood forest of the bottoms it has already been pointed out that humus is quite scanty. When these bottomlands burn over, therefore, the damage to the soil is probably slight. Compared to the fertility added by silt deposits over areas subject to overflow, the beneficial results of decaying surface material are apt to be small.

In seasons dry enough to allow fires to enter the cypress and tupelo type and the juniper type, damage to the soil is extremely severe, since it includes destruction of all vegetation growing in it. The peat of the juniper swamps and minor phases of the cypress and tupelo type, being over 90 per cent vegetable matter, is of course consumed practically in its entirety down to the water table. The mucks of the more important phases of the cypress and tupelo type are so largely composed of combustible material as to suffer almost equal damage.

On the other hand, fires in some ways create soil conditions favorable to forest growth. For example, since a mineral soil is the preferred seed-bed for many tree species, no doubt including the Southern pines, the burning away of litter fosters high germination, at least under favorable moisture conditions; when droughts follow the fall of seed the benefits of exposing the mineral soil may be materially lessened. There appears to be no Southern forest type in which litter interferes with the germination of a satisfactory number of pine seedlings. This holds true even for lands infested with scrubby oaks, under which the

litter is often abundant. Again, where the burned material was very abundant, as for example slash and down logs, a considerable amount of plant food is released by the fire, and causes very rank growth of succeeding vegetation. Loblolly pine seedlings up to 22 inches in height at the end of one season's growth have been observed on the site of burned logs. How long this effect lasts, and the advantage or disadvantage to the seedlings in the long run, can at present only be guessed.

Effect Upon Ground Cover and Underbrush

1. As forage. The fact that the great majority of fires in the Southern Coastal Plain, at least in those states still without any fire protective organization, are deliberately kindled by local residents in the belief that forage values are thereby improved compels a consideration of the scientific correctness of this belief, since as long as it persists fires are almost certain to occur. The effect of fire upon forage plants thus becomes a matter of the first importance to the silviculturist, although ordinarily out of his province.

The most important forage plant in the hardwood and cypress swamps is switch cane (Arundinaria sp.). This is fair winter forage for almost all classes of stock, and any one whose animals have access to a cane patch in good condition is generally sure of being able to winter them without loss. Fire destroys cane absolutely. In portions at least of the South it is a common thing for the "oldest inhabitants" to tell of the days when switch cane grew luxuriantly not only in the swamps, but in every little draw or depression leading out into the piney-woods. It seems to be fairly recognized that the incessant burning of the woods and cut-over lands is largely responsible for the alleged tremendous shrinkage in the area of cane.

There is no larger field for controversy over forest fires in the Coastal Plain than the effect of fire upon the upland types of forage. To begin with, there can be no doubt that in nearly every Southern state there has grown up during the last 50 years an over-whelming rural sentiment in favor of burning the woods in the late winter or early spring, in order to induce a new growth of the rooted grasses. Only with the establishment of a forestry department has the contrary feeling gained ground in any state. This custom perhaps had its origin in practices of the early inhabitants of the region. The Indians are said to have burned off occasional patches of woods here and there in order to attract game for easy slaughter.[1] The early white settlers also burned off small calf-pastures in the neighborhood of their dwellings, where the young calves and

[1] See footnote at end of page 20a

milk stock might graze in the spring without being tempted to scatter into the unfenced wilderness. One fact is certain, namely, that all classes of wild and domestic stock are attracted by the fresh spring of a "burn", and will congregate upon it to graze.

Whether the vegetation in a burn is actually earlier than in a "rough", or unburned spot, is decidedly to be questioned. In the Florida parishes of Louisiana a species of small daisy, said to be relished by sheep, has been found in bloom in the roughs during the latter part of January of

[1]At rare intervals large burns have undoubtedly resulted from lightning and been attributed to Indians.

a mild winter, while on a winter burn across a road these same plants were just putting out their first leaves, under similar conditions. A careful examination at the same time of the growth of the native rooted grasses on burned and unburned land, showed that there was at least 50 per cent more new growth among the old dead grasses of the rough than out on the bare blackened sand of the burn. Department Bulletin 827, states (6) :

"Cattlemen for generations have practiced burning the ranges in the winter or early spring because it makes earlier spring grazing. As a matter of fact, the grazing on burnt-over ranges is no earlier and may be considerably retarded. It should be done before the spring growth starts and not oftener than every three years, especially on heavily grazed pastures. Where a heavy growth of dead grass remains on the range during winter it affords considerable protection to the tender, growing parts underneath, so that some growth will be made even during winter. If the dead grass is burned in spring this protection is removed and much of the early growth that might be picked out by cattle is destroyed. Cattle prefer the burned pastures early in spring because of the ease of grazing, as they do not have to pick out the green from the dead grass and are able to get a quicker fill; but the carrying capacity of burnt range is no doubt lowered to a considerable degree by the injury done to growing plants. Burning the range year after year for so long a period has been injurious to the pastures to an extent difficult to estimate."

At least one competent authority ~~xxxxxxxxxxxxxx~~/believes the burning of wire grasses on pastured land in the Florida Peninsula at intervals of two or three years to be justified by the necessity of "freshening" the forage. ~~xxxxxxxxxxxxx~~/The progressive stockmen of that region do not believe in repeated annual burnings, however.

Fires affect not only the earliness of the spring growth, but have a profound effect upon the composition of the range vegetation. The following is a further quotation from Bulletin 827.

"Another effect of frequent fires on native pasture has been to keep out the desirable pasture grasses and perpetuate the undesirable ones. Wire grass and broom sedge have been able to withstand fires to such an extent that they have almost taken possession of the cut-over lands. These plants, although furnishing most of the grazing, are undesirable because of their short grazing season, and are no better adapted, except in their ability to withstand fire, than carpet grass and lespedeza, the two most valuable pasture plants found on the range.

"The reason for the ability of wire grass to withstand fire and not close grazing is not altogether apparent, but it is largely accounted for by the habit of growth and the season of growth. The grass is perennial, firmly rooted, and grows in clumps, the stools of which protect the growing parts from fire to some extent. The plant matures early in the season and the fuel for fires in the fall is largely the

dead stems and leaves of these plants. Thus it may be seen that fall fires come at a time when the plant has seeded and the season's growth is completed, while the spring fires do not affect the stools of the perennial plant as they do seedlings of annual plants and more tender perennials.

"Although carpet grass is a perennial that stands close grazing, it is very susceptible to fire. The seed is matured late in the fall, and the plant is still growing at the time of fall fires. In the spring the tender, creeping stalks are not protected to the same degree as are the clumps of wire grass and broom sedge.

"Lespedeza is seriously checked by fires because it is an annual which seeds late in fall at a time when fires are most likely to occur. Unshattered seeds are all destroyed and most of the seeds already dropped are destroyed, as they are loose and unprotected as compared with later in the season after beating rains have covered them with soil. The seeds are contained in a chaffy hull which burns readily. Spring fires come at a time when the seeds are germinating, or when the young plants are too tender to withstand fire.

"Without the destructive annual fires the soils of the cut-over lands and the distribution of grasses would have presented a different aspect; and since the damage done is apparent, immediate steps should be taken to prevent fires. However, occasional fires under proper control

may be used to remove accumulation of wire grass, and to check the growth of brush."

Conditions are occasionally found which point to fire as a valuable agent in the establishment of lespedeza. A luxuriant growth of lespedeza on heavily burned land may be accounted for by the fact that it finds its ideal seed-bed conditions on bare mineral soil and that the seed is distributed by cattle. A second fire, after the lespedeza is established, may wipe out the stand.

The hardest argument to answer in all of the stockmen's reperteire of excuses for burning the piney-woods range annually is the fact that fire temporarily cuts back the scrub oak and other underbrush on cut-over lands. ~~xxx~~ S.W. Greene has elsewhere stated (7): "In discussing the evil effects of burning I skipped what was perhaps the most important point of all. That was the black-jack and scrub oaks. Every man in this audience from southern Mississippi knows of some piece of old range land that is grown up to oaks until it is so thick that you cannot ride a horse through it. There is a reason for every oak thicket, and that reason is fire. If the cut-over land is not put into cultivation it is going to reforest itself, fire or no fire. If protected from fire the pine will keep down the scrub oaks, but if you burn the pines off the oaks will take possession. If the pines were as valueless as the oak they could still be gotten rid of easily; but if you cut down an oak

you get twenty-four oaks in its place. When it comes to making a pasture out of an oak thicket I absolutely throw up my hands".

One very striking illustration in the Louisiana longleaf pine belt of the effect of fire upon a pasture which was overgrown with blackjack oak may be cited.[1] Several hundred acres of typical longleaf pine cut-over land had been fenced and grazed for several years, probably to the limit of its carrying capacity. After about five or six years the native broom sedge and similar grasses in the openings between the clumps of oak had almost disappeared, being replaced by a beautiful turf of lespedesa and carpet grass. The close grazing had helped to make fire protection possible, and the scrub oak for several years had been undisturbed by fire. The result was a very marked raising of the crown level, as the oaks grew in height. The carpet grass and lespedeza, both very tolerant species, had crept into the thickets up to the very base of the trees, which were gradually thinning out as a result of competition. The previous spring a fire had entered a portion of this pasture, and had run through some of the oak thickets. By summer, instead of a single tall stem of oak, with the crown well cleared of the ground, there were, as Mr. Greene puts it, "twenty-four oaks" for each tree that had been there before the fire. These short oak sprouts cast a nearly complete shade on the ground, and the grasses and other forage underneath them, already severely injured

1. In Louisiana blackjack oak is the name most frequently given to Q. marilandica; in Florida blackjack oak is Q. catesbaei.

by the fire, were undoubtedly kept from recovery by the shade.

Palmetto in the piney-woods of the Florida Peninsula, and in bottomlands of the pine woods elsewhere in the Coastal Plain, presents another serious problem. It appears rather hopeless as a grazing proposition, and it may be that at least periodic fires are necessary to keep it somewhat in check.

2. As associates and competitors of trees. There is little well-established information on the indirect effect upon trees of fires burning in ground cover and underbrush. A few isolated relationships may, however, be tentatively stated.

The ordinary mixture of broom sedge and small herbaceous growth of portions of the Coastal Plain appears to have little effect in preventing the germination of pine seed. At Urania, La., newly-germinated longleaf pine seedlings have been found in very large numbers in a heavy growth of the vegetation which had resulted from about five years of fire protection and only light grazing. At the same place longleaf pine seedlings at the rate of five to six thousand per acre have successfully competed for ten years since germination with broom sedge, carpetgrass, and herbaceous ground cover on a plot (Roberts) from which stock were altogether excluded, and the seedlings are now of course long past the stage where so deep-rooted a tree is at all likely to be affected by ground cover or brush. On the other hand in

South Carolina, on a six-year "rough", heavily matted with wire grass, it appeared that ground cover might interfere with both the germination and survival of pine. A fire here would undoubtedly provide a better seed bed, and reduce the competition of the grass with the resultant seedlings. Conversion of the piney-woods range from native vegetation to carpet grass and lespedeza, under heavy grazing coupled with fire protection, has little effect on either germination or survival of pine seedlings, as again clearly proven at Urania over a period of several years; the danger of tramping becomes serious on such good range, however.

Herbs are unlikely to have any effect on the germination of Southern tree species; if they interfere with or foster development of seedlings there, seems to be no present evidence of such action. Fire damage to them is probably of little significance on that account.

Underbrush has occasionally been reported as interfering seriously with reproduction after establishment, and in such cases a fire prior to the seeding in of the tree species will of course favor them to the extent that it kills or cuts back the brush. Pine seedlings are uncommon under clumps of myrtle (Myrica cerifera) on cut-over land. Ashe suggests(8) burning in cut-over stands of mixed loblolly pine and hardwoods/in order to reduce the number of hardwood sprouts. prior to seeding of the pine ~~xxxxx xx xxxxxxx xx xxx xxxxx~~ A similar use of fire to remove buckvine, palmetto, and other underbrush for a few months

from hardwood swamps might help to give the hardwood tree species a chance in a good seed year. No doubt on most pine types scrub oak is detrimental to the pine, but on the deep sands (Norfolk series) of western Florida high oak shade is quite possibly an advantage to the longleaf pine, as shown by preliminary results from a current project at the Southern Station.(9) Since, as instanced above (p), fire does not often kill the oak, but changes it to low shade, burning in either case seems unlikely to favor associated tree species such as pine.

l.c. EFFECT UPON REPRODUCTION l.c.

The destruction of tree seed when the woods and cut-over lands burn has never been exactly measured, so far as known, but it probably would be very complete in every type except possibly the hardwood bottoms. Seed of all the important southern pines ripens in the fall and is disseminated either immediately or within a few weeks. Altho a portion of the seed crop, particularly the small seed of shortleaf, may be covered with soil by washing during heavy rains, the bulk of it must remain on the surface of the ground. Fires being very common thruout the winter and early spring undoubtedly destroy the unburied seed along with all other inflammable material on the ground. Fires burning in the dried muck and peat of cypress, tupelo, and juniper swamps consume the stored seed, which in the case of juniper land has been found to be incredibly abundant (as high as over three million seeds per acre). Hardwood seed is probably not as often destroyed

when the bottomlands burn as the seed of the conifers, partly because some hardwood species mature their seed several months before the fire season, and partly because the seed is contained in a fleshy or woody covering which insulates it against the heat.

The sand pine (P. clausa) is characterized by an interesting relationship between fires and seed dissemination. Most cones of this species open very slowly, and some may remain unopened on the tree indefinitely, being eventually buried in the wood of the branches on which they were borne. Fire opens such cones and liberates the seed, so that altho the mature or partially mature stand of trees may be killed, the ground a few months later will be green with seedlings.

Fires burning in the cypress and tupelo and juniper types completely destroy all reproduction. In the hardwood type they are likely to be fatal to the reproduction up to several inches in diameter. Inasmuch as practically all hardwoods of this size sprout readily, ~~xxxxxxxxxxxxxxxxx~~ fire is less apt to wipe out the species than to retard its development. Altho cypress has some sprouting capacity, the complete destruction of soil by fires in the cypress swamps causes death of the roots as well as stem, regardless of age of the trees.

Ordinary surface fires cause an incalculable annual loss in the form of seedling and sapling trees in the pine woods. First-year seedlings of all species are, as would appear inevitable, extremely sensitive to even the lightest fire.

No contrary observations have ever been made on this point, so far as known, and whenever in the cut-over pine lands of the South abundant pine reproduction of any species exists it is a practical certainty that through some chance the site escaped burning during the early months following germination of the seed, and has not burned every year after that.

The various species of pine differ very considerably in their resistance to fire after the first year of their life. Longleaf is the most resistant to fire. For the first five or six years its seedlings make an extremely small height-growth, according to Dr. Mohr not more than six inches on the average.(10) As the leaves persist on all of the Southern pines through at least the second season, and probably longer in the juvenile stages, the short stem of the longleaf seedling is protected from surface fires by a heavy growth of fascicled leaves beginning almost at the level of the ground.

Experiments have conclusively proven that beginning with the second winter, that is, fifteen to sixteen months after germination, young longleaf seedlings may be burned annually in the winter for four or five years without appreciable mortality.(11) This is even on land where grazing animals are excluded, and the surface vegetation is therefore more rank than it would be on grazed range. Annual fires did not kill the seedlings in these experiments, but singed off their leaves, leaving the bare stem topped by its winter bud, or caused the leaves to turn brown and finally drop off. However, a marked

stunting of the seedlings was apparent by the time they reached six years of age. Out of about 1700 longleaf seedlings in a carefully protected but otherwise comparable plot, 281 were more than two feet in height; on the repeatedly burned plot only 5 out of over 1500 exceeded two feet. The fires referred to were, of course, winter fires, started on days most favorable to light damage; nevertheless, they generally burned fiercely, and removed every trace of the lesser vegetation.

But after a few years of comparative immunity to killing by winter fires, longleaf pine seedlings again enter a brief period of danger. This is during their first vigorous height growth, when the lengthening stem no longer has needles to the ground, and has not yet developed a bark thick enough to exclude the heat of surface fires. It was found on the repeatedly burned plot at Urania that a considerable percentage of the longleaf seedlings between the heights of six inches and twenty-four inches were destroyed by the seventh consecutive fire. Of the eight year-old seedlings, 11.7 per cent were killed outright by this fire and an additional 8.0 per cent were killed back, but sprouted, probably with little chance of ultimate survival. That this loss was not wholly due to the weakening effect of early fires appears to be borne out by similar losses from a single winter fire, on areas which had not burned for several years, but on which more or less heavy grazing had reduced the hazard. The 1928 count at Urania showed a new loss of 31.9 per cent after the eighth fire, and it remains to be seen whether any appreciable number of long-

leaf seedlings on the repeatedly burned Roberts plot will pull through the fires of future years.

The size and age up to which longleaf pine seedlings remain subject to serious fire damage from occasional fires depends on the thickness of the stand, the amount of grazing, and the season of the year. Part of the Urania plot which had been protected against fire for a little over seven years was accidently burned in the winter of 1921. This fire killed 32.3 per cent of the seedlings and saplings, including some as tall as 4 to 5 feet, and killed back 6.2 per cent more. General observation points to the conclusion that an occasional fire burning in the winter time will thin out, but not decimate, longleaf pine reproduction after the first fifteen months. Just how far apart the periodic fires must be in order to permit the survival of a satisfactory stand is unknown. A summer fire, occurring during a drought in June, July, or August will wipe out entire stands of young growth.

The other pines are very much more sensitive to fire throughout their early life. Unlike the longleaf they begin vigorous height growth in the first or second year, and their stems, unprotected by a heavy cover of needles or by thick bark, are readily scorched and killed by even a light winter fire. There is but little experimental data upon the relative age at which shortleaf, loblolly, slash, and the other less important pines, are able to survive an ordinary winter fire. Reproduction less than ten or twelve feet in height, which normally means eight or ten years of age, is quite apt to be

killed by such a fire. It is possible that slash pine has a somewhat higher degree of resistance than the other pines. The damage done by fire undoubtedly varies with the density of the young stand, and the opportunities for the fire to sweep into the crowns. A summer fire may run through the crowns of a dense stand, such as found on an old field, and destroy trees well beyond the sapling classification. In a thick stand dead needles in considerable numbers are caught by the persistent lower limbs, and carry the flames into the tops.

Shortleaf pine has a considerable advantage over the other Southern pines in its ability to sprout when the main stem is killed by fire. As with hardwoods, such sprouts are very vigorous, and the unusual ability of one or two sprouts quickly to gain the ascendency over the others probably contributes to the continued vigorous growth. Few second-growth stands of shortleaf pine can be found which do not have a large proportion of these sprout trees.

The ability of shortleaf pine to sprout has been partly responsible for Mattoon's statement (12) that "abundant seeding, low resin content of the wood, and early rapid height growth, in addition to sprouting, afford shortleaf perhaps the best chance of any of the important Southern pines to survive under adverse conditions caused by fire..... ..... The heaviest direct injury to the stand occurs just after the ages of eight to twelve years, because prior to this time the young forest is quickly restored by

its power of coppicing. Repeated burnings, however, cause a set-back which the tree is able to make up only in part". Foster states that trees between these ages "are most susceptible to serious and permanent injury". (13 )

l.c. ——— EFFECT UPON IMMATURE TIMBER ——— l.c.

It is impossible to doubt that Southern stands of young timber of all species suffer a severe lessening of current growth as the result of a fire, even though it occurs in the winter and does not kill the trees outright. In this weakened condition they are more susceptible to attack by both insects and fungi than are healthy trees.

In sapling and pole pine stands the evidence of fire damage is the dying of foliage to a considerable height in the crown of the tree, probably due to heat killing. This reduction of the crown lessens the power of the tree to manufacture food, with a consequent slowing down of growth. No doubt the rapid growth of young pine stands on old fields is in part due to the lack of fires in such stands under ordinary conditions.

On the other hand W.W. Ashe (14) is of the opinion that "On loose, level, sandy, soils having the water table near the surface, where the trees do not suffer from drought, the yearly (winter) destruction of a large portion of the litter probably affects but slightly the growth of the trees" (mature loblolly, but mature according to North Carolina, not virgin growth, standards). On less favorable sites Ashe believes the destruction of surface litter by fires should be scrupulously prevented.

Summer fires are very much more destructive than winter ones. As an example of the heavy damage from summer fires in young pine stands may be mentioned the practically total destruction of the check plot on one series of thinnings established at Urania, Louisiana, in 1915. The fire occurred in August, and the 20-year-old trees were from four to nine inches in diameter and 50 to 65 feet tall. This was a very crowded stand of loblolly pine on an old field, and the complete destruction can undoubtedly be laid partly to the fact that the stand had not been burned for several years previous. The record shows a complete absence of undergrowth. The same fire, burning in the adjacent thinned stands, seems to have caused very few deaths. Emerging again into a portion of the stand in natural condition, this fire did a remarkably neat job of thinning, killing out the smaller and weaker trees for the most part, and sparing the larger ones. Whether the stimulating effect of the thinning was wholly or partly offset by the stunting of the surviving trees, there are no data available to prove. Akerman has reported an instance in Virginia of a 10-year-old loblolly stand which was thinned by fire, but in which the stunting effect of the fire appears to have more than offset the effect of the thinning.

As timber grows older, it is of course less apt to be seriously injured, even by fires during the growing season. Ashe (14) gives the following table to show the effect of an early summer fire upon a 50-year loblolly stand, burned seven years previous to his measurements. The undergrowth was gallberry and other shrubs, and the stand was said not to have burned before or since the fire referred to. This is a very unusual

situation, and by no means indicates what the effect of fires repeated thruout the life of this stand would have been.

The Effect of a Severe Brush Fire Upon the Growth in Diameter of Loblolly Pine.(a)

| Diameter breast high Inches | Number of trees measured | Width of 7 rings preceding the fire Inches | Width of 7 rings after the fire Inches |
|---|---|---|---|
| 7 | 2 | .3 | .2 |
| 8 | 2 | .3 | .15 |
| 9 | 4 | .5 | .3 |
| 10 | 3 | .7 | .3 |
| 11 | 5 | 1.1 | .6 |
| 12 | 2 | 1.0 | .6 |
| 13 | 3 | 1.1 | .9 |

(a) From Bulletin 24, N.C. Geological and Economic Survey "Loblolly or North Carolina Pine", by W.W. Ashe.

As a matter of general observation it is evident that loblolly and slash pine timber, both immature and mature, suffers more from fire than longleaf and shortleaf. The explanation lies undoubtedly in the ranker growth of vegetation in their wetter sites, since as will be seen on p. 42, shortleaf is not as resistant to a given amount of heat as loblolly.

In immature hardwood stands there is a very heavy loss from basal scarring and the inevitable entrance of fungi and insects. The bark of young trees is thin and affords little protection. In a young second-growth sweet gum stand in the Yazoo Delta of Mississippi, when the trees averaged about four inches in diameter, every tree over a considerable area showed

a basal fire scar. Thruout this forest fire scarring of young trees was a common phenomenon.

Immature timber, like reproduction, is killed outright by fires in the juniper and cypress and tupelo types.

A useful purpose is possibly served by fires in young timber when burning kills the lower limbs and encourages natural pruning.

l.c. ——— EFFECT UPON MATURE TIMBER ——— l.c.

Damage to mature hardwood timber is largely confined to destruction of the cambium and dying of the bark of a portion of the trunk, which is almost invariably followed by the entrance of fungi and insects. This process in immature stands has just been described. The enormous amount of rot in many of our Southern hardwoods is undoubtedly due in very large degree to fires. Dr. W. H. Long believes that 90 per cent of the rot in Southern hardwoods is traceable to fire injury. We know very little about the comparative susceptibility of the various hardwoods, but if the percentage of decay is a true index of the frequency of fire injury it is probable that overcup oak (Q. lyrata) is particularly severely damaged. A stand of nearly pure overcup oak in the Yazoo Delta was rejected as a current operation by the owners because of heavy defect. Occasionally large specimens of mature cypress are killed by the rare fires which enter the deep swamps, and the same is true of mature juniper.

Damage to mature stands of pine from surface fires does not seem to vary particularly with the species, though in the

aggregate, damage to longleaf pine is the heaviest. This is not due to greater susceptibility, but to more frequent fires.

A single fire rarely causes any noticeable damage in a stand of mature timber, unless it is a summer fire in a heavy stand of poles, in which case a very high proportion of the trees may be killed. But if grass or old limb wood fallen at the base of a large tree is kindled it often kills a small portion of the cambium. Although the injury may be hidden for years, the bark eventually loosens and falls off. The exposed wood is more or less covered by resin, and in the next fire this resin burns readily. This is repeated with each subsequent fire until the tree is so weakened as to blow over.

This damage is by no means confined to defective trees, or to those which have been turpentined. On a tract of mature longleaf timber in central Louisiana autumn fires in 1915 and 1917 burned down round (untapped) trees with a volume of 5-1/2 per cent of the stand, or about 490 board feet per acre. While some of the trees felled by fire were found to be defective, there were a good many perfectly sound specimens among them. It is very probable that the defect found was the result of previous fires. Frequently the fire continued to burn in the trunk for several feet after the tree was down. The actual volume loss in this case was equivalent to the annual taxes on the acreage burned.

There are no definite figures as to how general the fire

damage is in mature stands of Southern pine. The condition above described is not universal, although observed in many portions of the longleaf pine belt. One mill manager in Southwest Louisiana, altho believing in burning over his old-growth lands annually, found that it paid to employ a special crew to cut off the burning portions of trees felled by his fires! State Forester Holmes estimated that the fires of 1909 in North Carolina destroyed an average of 182 board feet of mature pine on each acre of merchantable timber burned over, or about 1.8 per cent of the volume of the stand. (15) He later reported (16) an April fire which killed 10 per cent of the mature "round" (unbled) longleaf timber on some 50 acres.

On the other hand there are a few portions of the longleaf pine belt where damage to mature standing timber is negligible or wholly lacking. One rarely sees a cat-face caused by fire in the longleaf pine woods on the deep sand of western Florida. This may be due to the openness of the stands or to the sparsity of inflammable ground cover.

The longleaf forests contain much limbwood and down material which, originally pitchy, appears to increase in pitch content with time. This "lightwood", as it is called, if burning at the base of a tree, makes a hot fire and by killing the cambium forms a scar. The smaller amount of lightwood in loblolly and shortleaf pine stands explains in a measure the less frequent burning down of those species.

Sand pine is very susceptible to fire injury, even when mature. Extremely thin bark, many small persistent limbs,

and density of stand combine to make severe damage possible.

l.c. —— EFFECT OF FIRES FROM SPECIAL HAZARDS —— l.c.

The foregoing statements have been made with respect to the effect of fire from the hazards normally existing in timbered lands, and in cut-over lands after the disappearance of slash and other debris resulting from logging. Discussion is also necessary of two special hazards: those created by turpentining, and those created by logging.

Turpentining.

As long as the trees are being actively worked for naval stores they are more or less effectively protected from fire by the raking. Occasionally fires will occur in the orchards toward the end of the chipping season and are communicated to the faces. Under these circumstances trees of all sizes large enough to be tapped are subject to very serious damage, frequently culminating in burning down, and at the least are so scorched, generally to the full height of the face - about eight feet on old workings - as to fall easy victims to fungi and insects.

The worst damage to turpentined timber occurs after the orchards are abandoned and raking is discontinued. Virgin timber owned by saw mills is today rarely left standing long after turpentining operations cease, but scattered trees on old cuttings are frequently not milled after tapping. Stands owned by farmers or other small holders are also apt to be tapped yeers before their further utilization. Under the

latter circumstances damage is cumulative, and complete destruction of the stand is inevitable in the long run. There is no definite information available on the average time required for this final catastrophe.

Slash.

The most destructive fires in the Southern Coastal Plain are in slash. Little escapes destruction because of the great heat produced by abundant fuel.

So far only one systematic study of the direct effect of slash fires has been made in this region.(3) This study was made in a slash area which burned during a dry autumn four to six weeks after cutting. The original stand was a mixture of shortleaf, loblolly and hardwoods, 15 to 20 thousand feet per acre, of which 80 per cent or more was cut. The fire was probably of maximum intensity for an autumn slash fire in this type. The following results were observed:

(1) The fire killed from 45 to 60 per cent of all trees over 8 inches in diameter, unless slash had been properly disposed. The trees which escaped were those more than 15 feet from heavy tops.

(2) Where tops were piled before burning in piles three to four feet high and eight to ten feet in diameter, trees were generally killed if within 15 feet of a pile, and severely injured if within 20 feet.

(3) Liability of all species combined to killing by slash fires varied with size; using trees above 13 inches

D. B. H. as the standard the damage was in the following ratios: over 13 inches, 1; 8 to 12 inches, 1-1/4; 4 to 7 inches, 2-1/2.

(4) Liability of all sizes combined to killing varied with species. Taking loblolly pine as unity, the number of dead white oak was 1.24, and of shortleaf pine, 2.0. It is quite possible that a chance preponderance of smaller trees among the white oaks and shortleaf pines caused some of the greater susceptibility to injury, although the data are based on from 200 to 300 trees of each species.

(5) The year following logging a loss of about half of the needles rendered unburned pine tops slightly less dangerous than shortly after cutting, whereas the persistent leaves of many of the hardwoods maintain the hazard practically at its early maximum.

Without further observation, the effect of slash fires under other conditions and in other stands cannot be appraised. Prof. H. H. Chapman of Yale has observed cuttings of mixed pine and inferior hardwoods in which slash fires apparently favored the reproduction of the more resistant pine.

The Bureau of Entomology suggests that carefully controlled slash burning may be valuable as an insect control measure in those areas where insects which normally work in slash may also attack adjacent standing timber.

## CONTROLLED BURNING

The custom of burning the woods and cut-over lands indiscriminately has become so firmly established among rural

people that it will take many years of education to eliminate fires. Knowing that a summer fire will do immense damage in pine stands, some have argued that fires at some season are inevitable and that it is better to burn the woods in winter under control, than to have an uncontrollable summer fire rage through the same land. They have accordingly urged the periodic winter burning of pine lands. In this way they hope to prevent the accumulation of inflammable material which may provide the fuel for destructive summer fires. Those interested in the future forest crop have stipulated that this should be done only after the trees have reached sufficient size to resist a winter fire.

Much of a theoretical nature may be advanced in defense of this idea. Already instances have been cited of stands which had been protected for several years, and then lost heavily in summer fires. One argument in favor of "light burning", however, seems to be very plainly open to objection even in the light of present knowledge. Particularly among the lumbermen, the majority of whom came from the Lake States where great accumulations of duff are the cause of fearful conflagrations, it has been said that unless the annual fall of pine and hardwood leaves, and the dead grass produced by the first autumn frost, are removed periodically by fire this vegetable matter will become so deep as to form a duff as menacing as that of the Lake States

and other northern regions. However, as earlier noted, an accumulation of more than three or four years' material is impossible in the piney-woods, under Southern conditions of moisture and warmth. Undoubtedly fire in such an accumulation is appreciably hotter and more destructive than fire in material produced in a single year. But the amount of fuel on the ground, as compared with the season of the year at which it burns, may be of minor consequence. General observation indicates that the leaf fall of a single year, if consumed by a summer fire, may do as much or greater damage than the accumulation of four years, consumed in the winter-time.

Controlled use of fire is questioned on several grounds. In the first place the controlled burning may not reduce the fire hazard. The effect of even a winter fire in causing pine foliage to wither and fall has already been noted. A virgin stand of shortleaf pine has been observed to burn over twice within a period of two months, the second time with most destructive effect. The area showed every evidence of having been burned annually for years. The first of the two fires mentioned occurred early in the spring. It cut back oak sprouts resulting from the fire of the previous autumn, and must have consumed whatever litter there was upon the ground very completely. In spite of this, the second fire, burning in early June, with the leaf fall of only two months to feed upon, burned trees twelve inches in diameter off the

stump. Such disastrous fires in the vegetative season are precisely what advocates of controlled burning aim to prevent. The earlier fire, which resembled a "controlled" burning, utterly failed to prevent serious damage from the later fire.

Again, a single fire does not always remove all of the inflammable material on the ground. A thicket of 10 or 12-year old loblolly pine, never before burned, on an old field in central Louisiana, was burned not long after rain during the month of June. Only the surface layer of pine straw was consumed, and a second fire would certainly have run through the same stand with extreme ease after the first prolonged drought.

A further objection to the use of fire for protective purposes is its cost. Anyone can, of course, set a fire in the piney-woods at a dry time in the winter and burn off several townships in a single day, if the wind is high. Such a fire would under ordinary circumstances certainly do a great deal of damage, and would not deserve the name of a "controlled" burning. When control is attempted the difficulty is that even in the comparatively flat Coastal Plain slight differences in elevation, growing into decided hills in some regions, are ample to cause a wide variation in the dampness of the leaf litter and other inflammable matter. If burning of a large tract is delayed until the surface is dry enough to burn cleanly and uniformly the ridges and higher slopes will have dried out to a dangerous degree. If on the other hand

fire is applied just as soon as the ridges are dry enough to ignite, the burn will be extremely patchy and the purpose of the burning will be to a large extent defeated. A satisfactory job of controlled burning requires plenty of labor available at the right time, with corresponding expense. Such expense may well be compared with the cost of constructing fire lines and protecting the tract in question by patrol and lookout.

An interesting experiment in the controlled use of fire on a large scale is being conducted on the Choctawhatchee Division of the Florida National Forest. From 1913 to 1920 fire was excluded from several thousand acres of this forest. The result was an extremely luxuriant growth of scrub oak, and practically no longleaf pine reproduction. (Drought in 1914 had wiped out the seedlings from the last big seed fall, that of 1913.) The intensive protection had cost in the neighborhood of 8¢ an acre a year during that time. In 1920 a new plan of handling the fire situation was adopted, and is now on trial. It was decided not to attempt complete protection of this area, but simply protection for a sufficient period to bring the young seedlings of each good seed year to an age where they can resist occasional fires. After that the only protection will be against disastrous summer fires.

In anticipation of the tremendous cone crop of 1920, the previously protected area was deliberately fired during the previous spring. The fire killed out a good deal of the scrub oak, and of course removed the seven years' accumula-

tion of hardwood leaves, dead grass, and similar litter. The seedlings germinating in the fall of 1920 were, under the plan, carefully guarded against fire at all seasons of the year until the late winters of 1923 and 1924, when the forest was to be burned off at a favorable time. Thereafter the entire area will be burned every two or three years, according to present plans, until the next heavy longleaf seed crop, which may be expected in 1926, '27, or '28.

## INVESTIGATIONS NEEDED

The foregoing compilation of what little is known or even surmised with respect to fires in the Southern Coastal Plain clearly indicates the need for their careful investigation. Altho the damage caused by fires is already apparent to the thinking portion of the public, an exact appraisal is necessary to real progress in control.

The following is a list of the silvicultural phases of the fire problem, which are in urgent need of study. (Economic and administrative problems are beyond the scope of this paper.) An attempt has been made to arrange them in the order of their importance within each forest type. Altho the pine type is more profoundly affected by fire than the other types, both quantitatively and qualitatively, certain fire problems of the hardwood type are certainly of greater importance than the minor problems of the pine type. Projects 1 to 4 in the hardwood type are ranked ahead of the last six enumerated projects in the pine type.

A thoroughgoing study of the direct and indirect silvicul-

tural effects of fires would cover almost the entire field of forest investigations in the South, because fire influences all the other factors of environment. For example, a study of natural reproduction is certain to involve a comparison of forest establishment on burned and unburned areas, because as a result of the burning such areas exhibit differences in the character of the seed bed, the intensity of competition following germination, and so on. An investigation of the relationship of timber-growing to stock-raising involves the burning of certain areas and the complete or partial protection of others. A study of methods of cutting is not complete without consideration of methods of brush disposal, which in turn may involve the use of fire. Silviculture and protection are therefore almost inextricably mingled in forest investigations in the Southern Coastal Plain. The precise point where a fire study stops and some other study begins is impossible to determine in some cases, but in the list given below an effort has been made not to go beyond the fire studies proper.

Pine type (four major species):

1. Effect of fire upon pine seedlings and saplings; as influenced by species, age, size, condition, density of stand, associated vegetation, soil, season of burning, and other factors. The great bulk of the forest lands of the Coastal Plain are cut-over lands, so that the effect of fires upon regeneration is of the first importance to Southern silviculture.

2. Effect of slash fires upon standing timber; as influenced by species, size, condition, distance from slash; character of slash disposal, age of slash, season of burning, and other factors. Unless seed trees are left on lands currently cut over, which amount to three million acres annually in the South, and these are in turn preserved against destruction by slash fires, natural reproduction will be extremely uncertain.

3. Effect of fire on ground cover and underbrush considered as stock range; with respect to composition, earliness, palatability and availability, removal of worthless vegetation. Altho not strictly a silvicultural problem, this project may yield information necessary to eliminate our most frequent cause of fires - burning to "improve" the range.

4. The effect of fire upon ground cover and underbrush, as associates or competitors of tree species, both before and after germination.

5. Effect of fire on immature timber, influenced by the factors listed in Project 1.

6. Effect of fire upon turpentined stands after abandonment; as influenced by species, age, size, severity of working, soil, season of burning, and other factors. The greater part of the present second-growth longleaf and slash pine in South Carolina, Georgia, Florida, and Alabama, has been turpentined before reaching sawlog size. The trees

are threatened with destruction from fire as soon as raking ceases.

7. Effect of fire on mature timber, as influenced by the factors listed in Project 1.

9. Use of fire under control as a protective measure; with respect to lessening of hazard, cost, and general feasibility.

10. Effect of fire on stored and surface seed.

11. Effect of fire on turpentined timber during protection by raking.

Pine type (minor species):

1. Effect of fire on stands of sand pine at all ages.

Hardwood type:

1. Effect of fire on immature timber in encouraging decay and insect attack; as influenced by species, age, size, condition, density of stand, soil, season of burning, and other factors. Because fires in most hardwood types come at intervals which give reproduction a chance to attain a size which is not killed, and because sprouting aids rapid recovery in any case, the indirect effects of fire are more important in the hardwood type as a whole than direct injury.

2. Effect of fires on mature timber in same manner as 1 above.

3. Effect of fire on seedlings and saplings; with respect to mortality, sprouting capacity, etc., as influenced

by factors listed in 1 above.

4. Effect of slash fires on standing timber with respect to species, age, size, condition, distance from slash, character of slash disposal, age of slash, season of burning, and other factors.

5. Effect of fire (other than under 1. above) on immature timber, as influenced by factors listed under 1. above.

6. Effect of fire on ground cover and underbrush, as associates or competitors of tree species, both before and after germination.

Minor projects. Effect of fires on stored and surface seed; on soil with respect to fertility, physical character, condition as seed bed; on ground cover and underbrush as stock range.

Southern White Cedar (Juniper) Type:

1. Effect of slash fire on standing timber, soil, etc., as influenced by condition of soil and season of burning.

Cypress and Tupelo Type:

1. As for paragraph 1 in previous type.

## CURRENT INVESTIGATIONS

The following briefly described projects established by the U. S. Forest Service appear to include practically all of the systematic work now being done on fire investigations in the Coastal Plain. One of the objects of this paper is

to encourage investigation of fires by all forestry agencies, and to point out the very large gaps to be filled. It is not intended, on the other hand, to discourage repetition or duplication of the work done by the Forest Service, which necessarily is on a small and quite inadequate scale.

Fire damage, loblolly pine. A series of sixteen plots, five or six in each of three age classes, from seedlings to poles, were established in 1925 at the Urania (La.) Branch Station. In each age class one plot is burned at each of the four seasons, and one remains unburned as a check plot. This project will help to solve the following problems among those listed above: 1, 4, 5, 8, and 10, pine type (four major species).

Fire damage, Longleaf pine. Two plots, in reproduction then 15 months old, were established at Urania in 1915. One is burned annually in the winter, and the other is kept unburned as a check. Five plots, in a sapling and small pole stand, were established at the McNeill (Bogalusa-McNeill) Branch Station, Mississippi, in 1923. One is burned at each of the four seasons, while the fifth remains unburned. These projects will help to solve the same problems as the loblolly project just described.

Fire damage, Shortleaf pine. Ten plots, five in a small pole stand, and five in a stand of saplings and seedlings, were established on the Arkansas National Forest in 1922. The treatment and purpose are the same as in the loblolly project. Neither series of shortleaf plots is entirely satisfactory for the study.

Fire damage, Slash pine. Six plots, in pairs on two different sites and in age classes from seedlings to poles, were established at Raiford, Fla. (Starke Branch Station) in 1924. One of each pair is burned during the winter, and the other protected against fire. The project is directed to the solution of the same problems as the loblolly project.

Slash disposal, shortleaf and loblolly pines and mixed hardwoods. Seven plots were laid out at Urania in 1921. Piling and pulling were the methods compared to no disposal at all; some areas were steam-skidded, others animal-logged. This project is identical with problem 2., pine type (four major species), and will throw some light on problem 4., hardwood type.

Grazing, longleaf pine. Two pastures of 160 acres each were fenced and put under observation at McNeill (Bogalusa-McNeill Branch Station) in 1923, in cooperation with the Bureaus of Animal Industry and Plant Industry and Mississippi Experiment Station. One is burned each winter, the other protected. All but ten acres in each are grazed, by cattle. This project is directed toward the solution of problem 3., pine type (four major species).

Various other projects of the Southern Station, notably a study of natural reproduction of longleaf pine on the Florida National Forest, altho not avowedly fire projects, involve a study of fire.

## SUMMARY

Forest fires in the Southern Coastal Plain have hitherto been very little studied. Generalizations concerning their effects are dangerous because of the wide variety of conditions in the region.

Both in number of fires and acreage burned over the Coastal Plain exceeds any other forest region. Deliberate burning to "improve" the range is the chief cause. Fires occur nearly annually in the pine type, particularly longleaf pine, but are comparatively rare in the wetter types.

Crown fires are very rare. Grass is the chief inflammable element in open stands and cut-over lands of the pine type, and litter in dense stands. Underbrush is occasionally a main fuel in the same type. In the hardwood bottoms vines and palmetto are important. Slash is very inflammable in every type except cypress and tupelo. Turpentining of pine timber creates a high extra hazard.

The fire season may be year-long, but normally covers the period from autumn frost or a little earlier until vegetation is well started in the spring. Erratic distribution of rainfall, which characterizes much of the region, may permit fires in any month.

Fires during the spring or summer are invariably destructive. Ordinary fall and winter fires have the following effects upon the pine type (other types are not included unless specifically mentioned):

1. Soil. Probably little immediate lowering of fertility, or even temporary increase, but injury to physical condition.

Complete destruction to water level of peat or duff in cedar, and cypress and tupelo, types.

2. Ground cover and underbrush. Reduction of grazing values, by encouragement of less valuable species of forage. Tendency to lower brush canopy without destroying it, with varying effect upon tree growth.

3. Reproduction. Destruction of seed on ground, and of seedlings of all species. Longleaf, which is remarkably resistant after first year, and shortleaf, which sprouts, are less susceptible than loblolly and slash.

4. Immature timber. Stunting of all species, and encouragement of decay in hardwoods particularly.

5. Mature timber. In hardwoods, as for young growth; in pine, often heavy loss from repeated fires.

Fires at the wrong season in turpentine orchards, or after the orchards are abandoned, are very destructive. Fires in undisposed slash are also extremely serious, but fire in properly disposed slash may have its uses.

Controlled burning to reduce hazard has never been given a trial, but its theoretical disadvantages xxxxxxxxxxxxxx outweigh xxxxxxx its advantages.

Investigations are needed of every phase of the fire problem in the Southern Coastal Plain. A limited amount of research is being currently conducted by the U.S. Forest Service in damage to the four principal pines, in brush disposal, and in the effect of fire upon forage values.

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